# Directed scale segments[*]

Roger Schwarzschild
*Rutgers University*

**Abstract**  If Jack is taller than Jill, there is a scale in which entities are ordered by height and which has a segment running from Jack down to Jill.   Call that a directed scale-segment. A comparative characterizes a directed scale segment by describing the two ends, the type of scale and optionally the length of the segment.  This paper explores the possibility of isolating these descriptions in distinct expressions in the clause tied together by quantification over directed scale segments.   Data from Hindi and Navajo are used to motivate this arrangement and then to probe its limits.  The resulting discussion is an argument for cross linguistic diversity in the semantics of comparatives.

**Keywords:**  Comparatives,  adpositions, directed scale segments, Hindi, Navajo

## 1   Spatial standard markers

The standard marker *than* is said to originally be the same word as the time adverb *then*.   Other sources for standard markers across the world's languages include conjunctions, case markers and adpositions, especially spatial ones.   My focus here will be on two languages, Hindi and Navajo, both of which employ as standard markers, postpositions with spatial uses.   Note the use of *–se* in the two Hindi examples below.

(1)   anu  raaj **se**      lambii    hai
        Anu  Raj FROM    tall.FEM   PRES.SNG

'Anu is taller than Raj'

(2)  anu   us        baRe    kamre       **se**      niklii
     Anu   that.OBL  big.OBL  room.OBL    FROM    come.out.PERF.FEM
     'Anu came out of that big room.'

What significance, if any, is there for the compositional semantics of a comparative that its standard is marked with a spatial postposition?  To answer this question, one might appeal to the similarity between points and paths in space on the one hand and ordered entities forming a scale on the other.  While this analogy is certainly germane, it doesn't answer the question posed.  According to nearly every current semantic analysis, scalar notions are present in comparatives regardless of how the standard is marked.  Instead I will pursue a different idea having to do with how information is distributed within the clause.  As illustration, I offer the pair in (3)-(4):

(3)  Jack ran from the room.
(4)  Jack left the room quickly.

Both sentences describe a movement path that starts at the room.  The verb in (3) describes the motion, but leaves any starting point implicit.  The prepositional phrase marks the room as a starting point but of what kind of path, it doesn't say.  The two combine to co-describe a single path.  By contrast, the verb in (4) describes the movement path and marks the object as the starting point.  The simple comparative *Jack is taller than Jill* describes a part of a scale, one that starts with Jill and goes up to Jack.  When an adposition meaning 'from' is used to form the comparative, it brings with it the ability to mark a starting point leaving for the rest of the clause to define the remainder of the scale part description. Thus information is meted out like in (3).

To execute incremental distribution of content within the clause, I will introduce an entity, to be called a **directed scale segment** which can be described in part by an AP or other gradable predicate and in part by a 'standard-PP', that is, a PP headed by a postpositional standard marker.

## 2   Directed scale segments

A directed segment is a segment of a line that has directionality.  The directed segment that goes from point A to point B is distinct from the directed segment that goes from B to A.  A scale segment is a part of a scale.  Putting these ideas together, a **directed scale segment** is defined by a scale and two points on that scale, one of which is the START point for the segment and the other its END point.

If the START is lower on the scale than the END we say that the segment is **rising**. In a **falling** segment, the START is higher on the scale than the END. I will use 'σ' as a variable over directed scale segments and '$\prec_\sigma$' will stand for the scale of which σ is a segment. '↗' will stand for rising and '↘' for falling. Henceforth, any reference to segments should be understood as reference to directed scale segments. The statements in (5) serve to summarize what's been said so far:

(5)    Let σ be a <u>directed scale segment</u> where: σ = $\langle s, e, \prec_\sigma \rangle$

$$\text{START}(\sigma) = s \qquad \nearrow(\sigma) \quad \textit{iff} \quad s \prec_\sigma e$$
$$\text{END}(\sigma) = e \qquad \searrow(\sigma) \quad \textit{iff} \quad e \prec_\sigma s$$

As I use the term here, a 'scale' has a **field,** which is just a set of entities, and the scale includes a **relation** on that set. If the field includes *a* and *b,* and the relation includes the pair <*a,b*>, we write '$a \succ b$'. The relation orders entities in the field. It is asymmetric, $(a \succ b) \Rightarrow \neg(b \succ a)$, and transitive. A scale also comes with a **measure** that characterizes the distances on the scale between entities in the field.

To illustrate how directed scale segments can be used in a semantics for comparatives, we return to the Hindi example from (1), *anu raaj-se lambii hai* 'Anu is taller than Raj'. In (6) below I provide what I call a 'semi-gloss' for (1). The semi-gloss uses English words but preserves some of the syntax of the original.

(6)    Anu from Raj is tall.

Meanings for the PP, the AP headed by *tall* and the entire clause are in (7)-(9):

(7)    ⟦**from Raj**⟧$^g$ = $\lambda P \, \exists \sigma \, \nearrow(\sigma) \wedge \text{START}(\sigma) = \text{Raj} \wedge P(\sigma)$

(8)    ⟦**tall**⟧$^g$ = $\lambda \sigma \, \lambda x \, \text{END}(\sigma) = x \wedge \prec_\sigma = \text{height}$

(9)    ⟦**Anu from Raj tall**⟧$^g$ =
$$\exists \sigma \, \nearrow(\sigma) \wedge \text{START}(\sigma) = \text{Raj} \wedge \text{END}(\sigma) = \text{Anu} \wedge \prec_\sigma = \text{height}$$

By "$\prec_\sigma$ = height" I mean that the scale of which σ is a part orders entities according to their height. The meaning in (9) can be read as: "There is a rising segment of the height scale that begins with Raj and ends with Anu."

The superscripted *g* in (7)-(9) is meant to be a contextually supplied function that assigns values to free variables and that plays the normal role in recursive rules for interpreting quantifiers. The assignment function will be relevant in

section 5, but the superscript will be suppressed from now on. The meaning in (8) is type $\langle d,\langle e,t\rangle\rangle$ where the domain of type $\langle d\rangle$ consists of directed scale segments. The meanings in (7) and (8) could not combine by function-argument application. There is a range of available options for dealing with such cases. In section 6, I'll mention a consideration for choosing among them. Finally, the interpreted expression in (7) presupposes Bhatt and Takahashi's (2011) conclusion that there is no elided clause preceding Hindi *–se* 'from'.

As promised, in (7)-(9), the PP and the AP co-describe a scale segment. In the next section, we'll look at differentials in Hindi. Their analysis will capitalize on the fact that adjectives take scale segment arguments. Following that we turn to recently discussed phenomena to do with comparatives in Navajo. There we will capitalize on the fact that standard-PPs quantify over directed scale segments.

## 3   Differentials in Hindi

When a differential is added to a comparative like (1), it shows up between the PP and the adjective:

(10)   anu  raaj  se      **do inc**  lambii    hai
        Anu  Raj  FROM  **2 inch**  tall.FEM  be.PRES.SNG
        'Anu is 2 inches taller than Raj.'

Let us assume that the measure phrase is part of an extended AP headed by *lambii* 'tall' and that it has the meaning in (11):

(11)   ⟦**2 inch**⟧ = $\lambda R\, \lambda\sigma\, \lambda x\, R(\sigma)(x) \wedge 2''(\sigma)$

The expression '$2''(\sigma)$' is to be interpreted as saying that the distance between the START and the END of $\sigma$ on the measure associated with the scale of $\sigma$ is 2 inches. Combining (11) with the meaning for *tall* we get (12) and then from there we get (13) as the meaning of a semi-gloss of (10):

(12)   ⟦**2 inch tall**⟧ = $\lambda\sigma\lambda x\, \text{END}(\sigma) = x \wedge \prec_\sigma = \text{height} \wedge 2''(\sigma)$

(13)   ⟦**Anu from Raj 2 inch tall**⟧ = $\exists\sigma\, \nearrow(\sigma) \wedge \text{START}(\sigma) = \text{Raj} \wedge \text{END}(\sigma) = \text{Anu}$
$$\wedge \prec_\sigma = \text{height} \wedge 2''(\sigma)$$

Analyzing differentials as modifiers accounts for their optionality. Leaving aside important exceptions in Chinese – transitive comparatives (Xiang 2005; Grano and Kennedy 2012) and differential verbal comparatives (Li 2009) – differentials are optional cross linguistically and most semantic analyses fail to predict that.

In Hindi, measure phrases appear in extended APs outside the comparative as well:

(14) anu **do inc** lambii hai
     'Anu is 2 inches tall'

The presence of a measure phrase alongside an adjective is dependent on the choice of the adjective. (14) contrasts with:

(15) **\*anu** caudah paunD b$^h$aari hai
     '\*Anu is 14 lbs heavy.'

*garam* 'hot' and *tez* 'fast' similarly resist measure phrase modification, while *puraanii* 'old.INANIMATE' and *cauRaa* 'wide' allow it. Interestingly, the sensitivity to the choice of adjectives is maintained in comparatives. (10) goes along with (14) and alongside (15) we have:

(16) \*anu raaj se **do** paunD b$^h$aarii hai
     Anu Raj FROM **2 lbs** heavy.FEM be.PRES.SNG
     'Anu is 2 pounds heavier than Raj.'

This pattern can be explained if we assume that the comparative and the positive are formed on the same measure-phrase containing extended AP.

    Sensitivity of measure phrase modification to the choice of adjective is well documented cross linguistically (Murphy 2006; Sawada and Grano 2011) but this sensitivity is usually limited to the positive. It is worth noting that in Hindi non-measure phrase differentials *bahut* and *kaafii* similarly fail to distinguish between comparative and positive uses of adjectives:[1]

(17) anu (raaj se) kaafii / bahut lambii hai
     Anu (Raj FROM) quite~a bit / very~a lot tall.FEM PRES.SNG

In (10), the differential measure phrase is lodged between the standard-PP and the adjective. This brings to mind an alternative syntax in which the measure phrase is a specifier inside an extended PP, like in the English *2 miles from here*

---

[1] Judgments concerning measure phrase modification in AP are insecure both within and across speakers. The presence of *zyaadaa* in the grammar of Hindi is a confounding factor. *zyaadaa* appears next to nouns in nominal comparatives (eg 'more water') and it can, and sometimes must, appear in adjectival and adverbial comparatives (Bhatt and Takahashi 2011: §3.1; Bhatt 2012). For example, alongside (1) we can have *anu raaj se zyaadaa lambii hai* and comparatives formed with *bimaar* 'sick' and *mazakiyaa* 'funny' must include *zyaadaa*. *zyaadaa* combines readily with measure phrase differentials – so judgments like those in (10) and (15) quickly turn into a decision about whether *zyaadaa* is necessary or not and introspection regarding its role in comparatives. My informants for Hindi were Veneeta Dayal, Ayesha Kidwai, Rajesh Bhatt, Utpal Lahiri and an anonymous woman at a bus stop in Piscataway.

(Svenonius 2010). There are several reasons to reject this analysis. First, it fails to capture the just discussed sensitivity to adjective choice shared by the positive and the comparative. Second, if the measure phrase were a specifier for the postposition, it would violate the general rule that specifiers in Hindi appear on the left of the head they specify. Third, when a *–se* PP has a spatial interpretation it cannot be followed by a measure phrase:

(18)　*hospital　　　yehaaN se　　do miil　hai
　　　　 hospital　　　　　 here　FROM　2 mile　be.PRES.SNG
　　　　 'The hospital is 2 miles from here.'

Finally, conjunction facts support an AP internal position for the measure phrase:

(19)　ye gaaRii us　　gaaRii-se　([do fuT lambii] aur [do saal puraanii]) hai
　　　　 this car　that.OBL car FROM　2 feet　long.F and　2 year old.F)　be.PRS.SG
　　　　 'This car is 2 feet longer and 2 years older than that car.'

Rett (2008a,b) analyzed a complex distribution of evaluativity judgments in terms of a modifier, EVAL, which is crucially able to combine with an adjective without interfering with further construction of a comparative or other type of degree idiom. According to the analysis proposed in this section, differentials in Hindi are another example of a modifier that combines with an adjective inside of a comparative. Yet another such modifier may be the inferiority marker *kam* found in (20) below, which can be interpreted as in (21):

(20)　ye gʰar　us　　gʰar　se　　(do saal)　kam puraanaa　hai
　　　　 this house　that.OBL house FROM　two year　little old.M　be.PRES.SNG
　　　　 'This house is (2 years) less old than that house.'

(21)　⟦**kam**⟧ = $\lambda R\, \lambda\sigma\, \lambda x.$ END$(\sigma) = x \land \exists\sigma'\ R(\sigma')(x)\ \land \prec_\sigma = $ INVERSE$(\prec_{\sigma'})$

(22)　INVERSE$(\prec_{\sigma'})$ is a scale with the same field and measure as $\prec_{\sigma'}$ but where the ordering relation is reversed.

## 4　Comparatives of inferiority in Navajo

Hindi happens to use a modifier in the AP to create comparatives of inferiority but given our meaning for the Hindi standard marker in (23) below, another logical possibility suggests itself.

(23)  $\llbracket\textbf{se}\rrbracket = \lambda x\, \lambda P\, \exists\sigma\, \nearrow(\sigma) \wedge \text{START}(\sigma) = x \wedge P(\sigma)$

A PP formed with (23) combines with an AP to create a comparative of superiority by requiring the directed scale segment it introduces to be rising. So a comparative of <u>inferiority</u> should in principle be expressible using a different postposition, one that quantifies over falling segments. This is apparently how it's done in Navajo.   (24) is a comparative of superiority, formed with the postposition -*lááh*. (25) is the corresponding comparative of inferiority, formed with the postposition -*'oh*.[2]  The meaning for the postposition in the comparative of inferiority is given in (26) and should be compared with the meaning in (23) above.

(24)  Shizhé'é     shi**lááh**         'aníłnééz
      1SG-father   1SGO-BEYOND   'á$_{CA}$-*ní*$_{CA}$-3S- ł$_{valence}$-tall$_{CA}$

      'My father is taller than I am.'

(25)  Shizhé'é     shi **'oh**        'aníłnééz
      1SG-father   1SGO-UNDER     'á$_{CA}$-*ní*$_{CA}$-3S- ł$_{valence}$-tall$_{CA}$

      'My father is less tall than me'

(26)  $\llbracket\textbf{'oh}\rrbracket = \lambda x\, \lambda P\, \exists\sigma\, \searrow(\sigma)\ \wedge \text{START}(\sigma) = x \wedge P(\sigma)$

With the meaning in (26) and a meaning for the gradable predicate as in our Hindi example we get a sentence meaning for (25) paraphraseable as "there is a falling segment of the height scale that starts with me and ends with my father".

## 5   Comparatives formed on POS adjectives

The gradable predicate in (24)-(25) is a verb. Several morphemes composing that verb have glosses subscripted 'CA' which stands for 'comparative aspect'. When those affixes are employed, the verb must be used in a degree construction such as the comparative, the equative or a degree question.  To simply assert that someone is tall, one needs to use a different form of the verb, as in (27), where the subscript POS in the gloss stands for 'positive':

(27)  shádí                nineez
      my-older.sister    ni$_{POS}$ -3S-$\varnothing_{POS}$-tall $_{POS}$
      'my older sister is tall'

---

[2] The translation for -*'oh* differs across sources.  Except for this word, the Navajo examples in this paper and their glosses are from Bogal-Albritten 2008, 2010 or 2011.

The use of POS morphemes in this example entails the presence of evaluativity – my sister's height is understood to meet or exceed a contextual norm. I'll assume then that there is a POS operator in the logical form and I'll semi-gloss (27) as in (28) where the $C$ subscript is a quantifier domain restrictor:

(28) My older sister is $\text{POS}_C$ tall

A POS operator has two functions. First, it binds the $\langle d \rangle$-type argument of a gradable predicate and secondly, it introduces dependence on context. Bogal-Allbritten (2010, 2011) argues convincingly for a Rettian analysis of adjectival verbs in which the two functions of POS are separated out. I've implemented this separation below[3] by relegating the context dependence to a constraint on the assignment of values to the domain-restricting variable, $C$.

(29) $⟦\text{POS}_C \ tall⟧ = \lambda x \ \exists \sigma \in C \ (\text{END}(\sigma) = x \wedge \succ_\sigma = \text{height})$

(30) $⟦\text{POS}_C⟧ = \lambda R \ \lambda x \ \exists \sigma \in C \ (R(\sigma)(x))$

(31) Constraint on the assignment of values to $C$ in structure $\textbf{POS}_C$ by function $g$ supplied by discourse $\Delta$

$\forall \sigma \ (\sigma \in g(C) \rightarrow \text{START}(\sigma)$ and $\text{END}(\sigma)$ are individuals on what counts in discourse $\Delta$ as the top end of the scale $\prec_\sigma$)

From (29)-(31) it now follows that if (28) is true in a discourse $\Delta$, then my older sister is on what counts in $\Delta$ as the top end of the height scale.

Unlike the CA marked verb in (24), the POS marked verb in (27) should not be expected to combine with the standard-PP in (24). That PP is a segment quantifier but the segment argument of the verb in (27) is bound off by POS, as (29) shows. As predicted, the verb in (27) does resist combination with a standard-PP – direct combination, that is. There is a second kind of comparative formed by combining the PP with the word *'át'ée=go* and then with a POS marked verb:

(32) shimá　　　[shádí　　　　yiláah　　　'át'ée=go]　　　nineez

---

[3] Francez and Koontz-Garboden (2011) likewise treat the context dependence of positives in Ulwa via contextual domain restriction. (31) uses the expression 'top end of the scale' taken from Cresswell's (1976: 272) discussion of *Bill is a tall man*. Cresswell considers an alternative meaning: "tall enough to make it sensible to distinguish Bill from other men." See Kennedy 2007a: 17ff for development along these lines. (30)-(31) is a different implementation than Bogal-Allbritten's and presents a simplified picture of the evaluativity facts.

my-mother  my-older.sister  3O-BEYOND  3S-be-COMP     ni$_{POS}$ -3S-$\varnothing$$_{POS}$-tall
'My mother is taller than my older sister.'

Young and Morgan (1987: 193) gloss *'át'ée=go* as 'it being'. Their choice of the gerund appears to capture the fact that *=go* marked expressions serve as adjuncts. Schauber 1979 discusses temporal, conditional and causal *=go* adjuncts. Here's a conditional example from page 224 of that work (COMP is for 'complementizer'):

(33)  [Łį́į́    síníloh**go**]        shizhé'é   neidiyooɫnih
      Horse  2.PERF.rope.**COMP**   1SG.father    3.3.FUT.buy
      'If you rope a horse,  my father will buy it.'

von Fintel 1994: §3.3 proposes a compositional semantics for *if* clauses that relies on the presence of an operator – a modal or adverb of quantification – that has a domain variable index whose value, supplied by context, restricts the domain of the operator. The meaning of the *if* clause is intersected with the value of the domain variable further restricting the domain of the operator. Suppose we take the complementizer *=go* as a signal that the clause it combines with is to be used to restrict the domain of a quantifier. von Fintel's analysis could apply in (33) with a future operator on the verb bearing the domain variable index. Applying these ideas now to (32) means taking the bracketed expression to be a quantifier domain restrictor. The POS operator associated with the verb can then be the quantifier whose domain is restricted. These ideas are summarized in the semi-gloss for (32) given below in (34):

(34)  My mother [(be (BEYOND my sister))-COMP$_C$]  is POS$_C$  tall

Following von Fintel, I coindex the operator, in this case POS, and the domain-restriction-marker, in this case COMP.

The word *'át'ée=go* is formed by attaching the complementizer *=go* to *'át'ée* which is a copula: hence the 'be' in our semi-gloss. Bogal-Albritten (2010: 12) writes that the copula must be used given that *=go* "primarily marks clausal constituents". This may be so, but the copula can fulfill a semantic function as well. As (30) shows, POS quantifies over scale segments, so its domain must be a set of scale segments and so an expression that restricts its domain needs to denote a set of scale segments. But the PP *beyond my sister* denotes an existential quantifier over scale segments, as shown in (36) below. What is needed is the type shifting functor 'BE' of Partee 1987:

(35)  BE = $\lambda\mathcal{P}_{<<e,t>,t>}\lambda x. \{x\} \in \mathcal{P}$   *or equivalently*  BE = $\lambda\mathcal{P}\lambda x. \mathcal{P}(\lambda y\, y = x)$

The semantics for the bracketed adjunct in (32)/(34) develops as follows:

(36) $[\![\textbf{beyond Sister}]\!] = \lambda P \, \exists \sigma \, \nearrow(\sigma) \wedge \text{START}(\sigma) = \text{Sister} \wedge P(\sigma)$

(37) $[\![\textbf{be beyond Sister}]\!] = \text{BE}([\![\textbf{beyond Sister}]\!]) = \lambda \sigma \, \nearrow(\sigma) \wedge \text{START}(\sigma) = \text{Sister}$

(38) $[\![[\textbf{be beyond Sister } \text{COMP}_C]]\!] = \lambda S \, \lambda x \, (C \subseteq \lambda \sigma \nearrow(\sigma) \wedge \text{START}(\sigma) = \text{Sister}) \wedge S(x)$

In (38), I assumed that COMP takes $C$ as its first argument and that it has the following meaning.[4]

(39) $[\![\text{COMP}]\!] = \lambda P \, \lambda Q \, \lambda S \, \lambda x \, (P \subseteq Q \wedge S(x))$

When the verb and the subject are added, (32)/(34) has the semantics in (40):

(40) $\exists \sigma \, (\text{END}(\sigma) = \text{Mother} \wedge \succ_\sigma = \text{height} \wedge \nearrow(\sigma) \wedge \text{START}(\sigma) = \text{Sister})$

Now if we fold in the constraint on $C$ values from (31) above, we get a meaning paraphraseable as:

(41) There is a rising segment of the height scale that begins with my older sister and ends with my mother, both of whom are on the top end of the height scale.

(41) comports with the speaker's paraphrase of (32) reported in Bogal-Allbritten 2011: 7: "They're both very tall, but my mother is even taller."

    The POS quantifier comes with a domain variable, so by uniformity, we should posit one for the standard-PP quantifier as well, which in turn leads to the expectation that some adjunct might serve to constrain its values. This may well be what happens with differentials in Navajo. In Bogal-Allbritten's (2008) example (33a), glossed as 'Susan is six inches taller than Mary', the measure phrase plus postposition *yee* '3sgO-WITH' appears to the left and adjacent to the standard-PP. The measure-phrase+postposition might limit the domain of the standard-PP quantifier to six inch segments. The rest of the composition is too ungainly to mention.

    In this section, we've shown how a standard-PP can perform its function via quantifier domain restriction and we've given an account of why the copula and the =*go* complementizer are used for that purpose. In Schwarzschild to-appear, I

---

[4] Alternatively, we could adapt von Fintel's rule for conditionals: $[\![if_i \text{ p, q}]\!]^g = [\![q]\!]^{g[\, i \, \rightarrow \, (\, g(i) \, \cap \, [\![p]\!]\,) \,]}$.

called PPs used in this way 'quantifier domain adverbials' and I developed the idea that quantifier domain adverbialization provides a key to understanding the genesis and grammar of so-called comparative markers. Returning to our central theme, observe that the analysis offered crucially depends on the fact that the standard-PP is a segment quantifier that encodes some of the meaning of the comparative.

## 6  Complex gradables

The Hindi and Navajo examples considered so far were restricted to those in which the subject of the sentence is an argument of the gradable predicate. In (42) below, this restriction is lifted:

(42)  anu-ne      raaj-se          garam cai   banaaii
       Anu-ERG  Raj-FROM       hot      tea     make.PFV.FEM
       'Anu made hotter tea than Raj made'

The scale at issue in this example is one in which entities are ordered by their temperature. That scale is introduced with the adjective *garam* 'hot'. Raj is not on that scale, or at least his position on that scale is not relevant to the truth conditions registered in the gloss. Nevertheless, the standard-PP will introduce a scale segment that has Raj as its START and then the adjective will say that the scale is a temperature scale. We seem to be moving in the wrong direction.[5]

At least since Heim 1985, the starting point for pretty much any analysis of comparatives like (42) is the observation that Raj and Anu are being compared relative to how hot they make the tea, so we need to form in the syntax a complex gradable predicate. As a starting point, I'm going to assume that in (42), *anu-ne* combines with a predicate of type $\langle e,t \rangle$ and that *raaj-se* combines directly with the adjective *garam* 'hot'. These assumptions inform the semi-gloss below:

(43)   Anu [$_{\langle et \rangle}$ made ((from Raj hot) tea)]

---

[5] Speakers prefer a habitual variant of (42) where the verb is imperfective. I ignored that here because the intended reading may well be one in which the PP quantifies into an intensional context. Under the influence of Bale 2007, I constructed my scales out of individuals. This is probably unworkable when standard-PPs quantify into intensional contexts. In that case, segments will have to be triples of two degrees and a function assigning degrees to entities. I try to give an idea of how that might look with the meaning below, where $\delta_\sigma$ stands for the degree assigning function associated with σ.

$$[\![\textbf{tall}]\!]^g = \lambda w\, \lambda\sigma\, \lambda x\ \text{END}(\sigma) \leq \delta_\sigma(w,x) \wedge \delta_\sigma = \text{height}$$

I found no motivation for degree-scales other than for quantifying in. That surprised me (see related EXERCISE in footnote 7). By the way, given the measures assumed in earlier sections, there's no question here of avoiding abstractness by avoiding degrees.

The standard-PP now moves out of its base position to a spot below the subject thereby creating a predicate of type $\langle d,\langle e,t\rangle\rangle$:

(44)   Anu [from Raj]  $[_{<d,<et>>}$ $\lambda t_d$ $[_{<et>}$ made $((t_d$ hot) tea)] ]

The newly created $\langle d,\langle e,t\rangle\rangle$ type predicate is a complex gradable with the meaning in (45):

(45)   $[\![\lambda t_d \text{ (made } ((t_d \text{ hot) tea))}]\!](\sigma)(x) = 1$  *iff*   $x$ made hot tea and $\sigma$ is a segment of the heat scale that ends in the tea that $x$ made

If we stop here, we do not solve the problem. We still have segments of the heat-scale and the PP in (44) places Raj at the START of one of them. In the remainder of this section, I will sketch two solutions to this problem, one that revises the meaning of the standard-PP and one that leaves it intact operating on the scope of the PP. One solution will work for Hindi and the other for Navajo.

    The first solution revises the meaning of the standard marking postposition *se* to (46) which leads to the meaning for the standard-PP in (47).

(46)   $[\![-se]\!] = \lambda x \lambda R\, \lambda y\, \exists \sigma\, \nearrow(\sigma) \wedge \exists \sigma'\, R(x, \sigma') \wedge \text{START}(\sigma) = \text{END}(\sigma') \wedge R(y, \sigma).$

(47)   $[\![\textbf{from Raj}]\!] = \lambda R\, \lambda y\, \exists \sigma\, \nearrow(\sigma) \wedge \exists \sigma'\, R(Raj, \sigma') \wedge \text{START}(\sigma) = \text{END}(\sigma') \wedge R(y, \sigma).$

If we now apply the meaning in (47) to the one in (45) and then apply the result to Anu we get (48) which amounts to (49):

(48)   $\exists \sigma\, \nearrow(\sigma) \wedge \exists \sigma'\, \sigma'$ is a segment of the heat scale that ends in the tea that Raj made $\wedge$ START$(\sigma) = $ END$(\sigma') \wedge \sigma$ is a segment of the heat scale that ends in the tea that Anu made.

(49)   There is a rising segment of the heat scale that starts with Raj's tea and ends with Anu's.

The second solution locates the problem in the meaning of the complex gradable formed as a result of movement. The meaning in (45) is a type $\langle d,\langle e,t\rangle\rangle$ function but it differs from the other functions of this type discussed above. Those functions always paired a segment with an individual at its end. The meaning in (45) doesn't do that. This motivates the definition of an operator that can apply to

such an errant meaning and produce a proper one. We'll represent the operator with a rotated scale symbol, '⅄', and we'll call it the **adge operator**.[6] In (50), I give the intended meaning of the result of appending ⅄ to the complex gradable from (44)-(45):

(50) $⟦^⅄(\lambda t_d \ (\textbf{made} \ ((t_d \ \textbf{hot}) \ \textbf{tea})))⟧(\sigma)(x) = 1$    *iff*    $x$ made hot tea and $\sigma$ is a segment of a scale that orders tea-makers by the temperature of their tea and $\text{END}(\sigma) = x$.

And now the LF in (51) below gets the interpretation paraphrased in (52):

(51) Anu [from Raj] $^⅄(\lambda t_d \ (\text{made} \ ((t_d \ \text{hot}) \ \text{tea})))$

(52) There is a rising segment of the scale that orders tea-makers by the temperature of their tea and it starts with Raj and ends with Anu.

I hope (50) provides a good sense of the semantics of ⅄. In (53)-(57) below, I attempt to define it. For each statement, I'll say what effect it has in the case of (50).

Let ⅄ be an operator of type $⟨⟨d,⟨e,t⟩⟩,⟨d,⟨e,t⟩⟩⟩$ and let $R$ be a variable of type $⟨d,⟨e,t⟩⟩$. Free variables in definitions are to be understood as universally quantified. ⅄ is defined for a function $R$ only if:

(53) $(R(x,\sigma) \wedge R(y,\sigma') \rightarrow \prec_\sigma = \prec_{\sigma'})$

(54) $(R(x,\sigma) \wedge R(x,\sigma') \rightarrow \text{END}(\sigma) = \text{END}(\sigma'))$

(53) guarantees that all segments paired with Anu or Raj will be segments of the same scale, the heat scale, and (54) guarantees that all segments paired with Anu end with the same tea. (54) is an admittedly strong simplifying assumption.

Given (53), it makes sense to talk about 'the scale associated with $R$' abbreviated $\prec_R$. We'll now define the scale associated with $⅄(R)$ which we'll symbolize as $\prec_{\text{adge}(R)}$. Recall a scale consists of a field, an ordering and a measure. We now define those for $\prec_{\text{adge}(R)}$:

(55) $\text{Field}(\prec_{\text{adge}(R)}) = \{x : \exists \sigma \ R(x,\sigma)\}$

(56) For any $a, b, \sigma_a, \sigma_b$ such that: $R(a, \sigma_a) \wedge R(b, \sigma_b)$

---

[6] nom:nominalization :: adge:adjectivalization

$$a \succ_{\text{adge}(R)} b \ \leftrightarrow \ \text{END}(\sigma_a) \succ_R \text{END}(\sigma_b)$$

$$|a-b| = |\text{END}(\sigma_a) - \text{END}(\sigma_b)|$$

(55) guarantees that the new scale in (50) orders Raj and Anu and not their teas. (56) guarantees that Anu is above Raj on the new scale if her tea is above his on the old scale and the distance between Anu and Raj on the new scale is given by the temperature difference between their teas.

With $\prec_{\text{adge}(R)}$ defined, we can now spell out the function denoted by $\lambda(R)$:

(57) $[\lambda(R)](\sigma)(x) = 1$ *iff* $\text{END}(\sigma) = x$ and $\prec_\sigma \ = \ \prec_{\text{adge}(R)}$

We now have two solutions to the problem we began with. One solution, we'll call it '$\lambda R$', raises the type of the standard-PP. The other utilizes the adge operator and we'll call it '$\lambda R$'. $\lambda R$ preserve the advantages for Hindi differentials discussed earlier. We can continue to treat the differentials as optional AP modifiers. To see this consider the meaning we get for our earlier example using the new PP meaning in (47):

(58) ⟦**2 inch tall**⟧ $= \lambda\sigma\lambda x \ \text{END}(\sigma) = x \ \wedge \ \prec_\sigma \ = \text{height} \ \wedge \ 2''(\sigma)$

(59) ⟦**Anu from Raj 2 inch tall**⟧ $= \ \exists\sigma \ \nearrow(\sigma) \ \wedge \ \exists\sigma' \ \text{END}(\sigma') = \text{Raj} \ \wedge \ \prec_{\sigma'} \ = \text{height} \ \wedge \ 2''(\sigma') \ \wedge \ \text{START}(\sigma) = \text{END}(\sigma') \ \wedge \ \text{END}(\sigma) = \text{Anu} \ \wedge \ \prec_\sigma \ = \text{height} \ \wedge \ 2''(\sigma)$

Compare (59) to what we had earlier, repeated in (60):

(60) ⟦**Anu from Raj 2 inch tall**⟧ $= \ \exists\sigma \ \nearrow(\sigma) \ \wedge \ \text{START}(\sigma) = \text{Raj} \ \wedge \ \text{END}(\sigma) = \text{Anu} \ \wedge \ \prec_\sigma \ = \text{height} \ \wedge \ 2''(\sigma)$

They differ by the information in (59) concerning $\sigma'$. The fact that $\sigma'$ is a segment of the height scale requires Raj to have a height. That requirement is similarly imposed in (60). The fact that $\sigma'$ is 2" long in fact has no ramifications. No matter what Raj's height is, there will be a 2 inch long falling segment that ends with Raj.

$\lambda R$ is not compatible with our analysis of Navajo POS-comparatives. That analysis relied on applying the Partee BE operator to the PP quantifier. The $\lambda R$ meaning for the standard-PP is the wrong type for BE to apply to (the problem could be deeper). The $\lambda R$ analysis, on the other hand, leaves the PP meaning intact so it is a viable alternative for Navajo. But $\lambda R$ spells trouble for Hindi.

The adge operator doesn't pay attention to the lengths of the segments in the relation it applies to. So when an adge operator is attached to an AP it will wipe out any information contributed by a differential MP in that AP. The net result then is that $\lambda R$ is best for Hindi and $\curlywedge R$ is best for Navajo.[7]

I've been assuming that the adge operator is attached to a predicate created by quantifier movement. This type of arrangement has been adopted elsewhere (see Dotlačil 2010: 61 and refs. therein), though some may find it objectionable. It may not be necessary. I do not know what complex gradables, if any, are possible in Navajo. I've relied in this paper on Bogal-Albritten's work for nearly all facts Navajo and she does not discuss examples like our Hindi hot tea sentence. Young and Morgan 1987: 193 have nominal comparatives (eg 'I earned less money than you') that likely involve complex gradable predicates. These examples use *'át'ée=go* and so it might be that all complex gradables in Navajo are formed in POS comparatives. If so, we can implement the $\curlywedge R$ analysis by modifying the meaning of POS as in (61) below,[8] letting complex gradables be formed by POS movement, as in Schwarz 2010.

(61)   $[\![POS_C]\!] = \lambda R \, \lambda x \, \exists \sigma \in C \, (^\curlywedge R \, (\sigma)(x))$

We have converged on the idea that $\lambda R$ is right for Hindi and $\curlywedge R$ is right for Navajo and we turn now to some further theoretical considerations. By the logic of Heim 2001: 215, there is a type mismatch in '((from Raj) hot)' in (43). The mismatch triggers quantifier raising and that is what gives rise to a complex gradable predicate in (44). This reasoning is undermined by $\lambda R$. Raising the type of the PP eliminates the mismatch.

The relational variable $R$ occurs twice in the $\lambda R$ meaning for *–se*, once applied to $x$ and once to $y$:

(62)   $[\![-se]\!] = \lambda x \lambda R \, \lambda y \, \exists \sigma \, \nearrow(\sigma) \wedge \exists \sigma' \, R(x, \sigma') \wedge \text{START}(\sigma) = \text{END}(\sigma') \wedge R(y, \sigma).$

In this respect, it hews closely to the "direct analysis" of phrasal comparatives in Heim 1985, applied in Kennedy 2007a to standard morphemes. As in that analysis, two operations are combined: a 2-place relation is upgraded to a 3-place relation and superiority is introduced. The $\curlywedge R$ analysis can be taken to demonstrate that these two operations are separable and if in some cases they

---

[7] EXERCISE    Calculate the meanings for "Anu from-Raj loves Boman". Let *love* be type $\langle d, \langle e, \langle e,t \rangle \rangle \rangle$. Consider a scale whose field consists of pairs $<a,b>$ that are ordered based on the intensity of $a$'s love for $b$. Find LFs meaning 'Anu loves Boman more than Raj does' and 'Anu loves Boman more than she loves Raj'. Try this with $\lambda R$ and with $\curlywedge R$.

[8] I believe $\curlywedge$ is harmless when applied to a simple gradable verb.

need to be combined, then it isn't complex gradables per se that require it, assuming our reasoning above was correct.

## 7    Conclusion

If Jack is taller than Jill then there exists a directed segment of a height scale that runs from Jack to Jill.  I've proposed that some languages employ a logic in which there is quantification over directed scale segments.  This logic permits AP modifiers in Hindi to function as differentials and as an inferiority marker.  The logic is fully exploited in Navajo where standard-PPs combine with a predicative BE to produce a segment-predicate which then serves as a domain restrictor for a verbal segment quantifier.  And Navajo has inferiority standard markers which arise naturally in this setting.[9]

Across the world's languages, standard markers are drawn from a variety of sources.  These items usually retain source syntax in their standard-marking guise.  In this paper, I have adopted the hypothesis that aspects of the source semantics is similarly retained.  Spatial adpositions are used in incremental descriptions of a path and they preserve this incrementality in their standard-marking guise. This hypothesis could also be discerned in Pancheva's (2006) discussion of the Bulgarian preposition *ot*. *ot* is used in the partitive ('two of the girls') and Pancheva argues that standard-marking *ot* is a partitive preposition in the domain of degrees.  It more or less follows from the view taken here that standard markers will differ in their semantics across languages, depending on their source.  Above, I tentatively concluded that Hindi and Navajo differ in their standard marker semantics.  In retrospect, this is unsurprising given the diversity in the kinds of postpositions the two languages use.  Even within a single language, we expect two standard markers with different sources to have different syntax and different semantics (see Merchant 2012 for a relevant case).

**References**

---

[9] Faller's and Winter's proposals for a **vector space** semantics for comparatives served as an important starting point for this paper and the analysis of differentials in Hindi follows their approach quite closely.  For any directed segment $S$, there is a vector $v$ which is the set of segments that have the same length and direction as $S$.  So a vector is completely defined by a length and a direction.  In two or three-dimensional space, the angle between two vectors $u$ and $v$ is the angle between the directions of segments in $u$ and $v$.  Zwarts 1997 used vector spaces for PP modifiers such as *kitty corner* and *2 miles* which respectively describe an angle and a length. Since vectors do not have a position in space, they do not seem to be the right object to do the work proposed here for directed scale segments.  And since the angle between segments played no role here, vector spaces introduce unmotivated complication (at SALT, Manfred Krifka did suggest to me ways vector addition could be relevant).

Bale, Alan. 2007. Boolean AND and the semantic correlates of gradable adjectives. Handout for *International Conference on Adjectives. Lille* (France), 13 – 15 September 2007.

Bhatt, Rajesh. 2012. Many or more: the Hindi-Urdu degree word *zyaadaa* and the analysis of bare comparatives. ms.

Bhatt, Rajesh and Shoichi Takahashi. 2011. Reduced and unreduced phrasal comparatives. *Natural Language & Linguistic Theory* 29.3:581-620.

Bogal-Allbritten, Elizabeth. 2008. *Gradability and Degree Constructions in Navajo*. B.A. thesis, Swarthmore College.

Bogal-Allbritten, Elizabeth. 2010. Decomposing adjectival meaning in Navajo. ms.

Bogal-Allbritten, Elizabeth. to appear. Positively uninformative. In M.Y. Erlewine (ed.) *MIT Conference on Comparatives*, Cambridge, MA: MIT Working Papers in Linguistics.

Cresswell, Max J. 1976. The semantics of degree. In Barbara Partee (ed.) *Montague Grammar*, 261-292. New York: Academic Press.

Dotlačil, Jakub. 2010. *Anaphora and Distributivity. A Study of **same**, **different**, Reciprocals and **others***. UIL-OTS, Utrecht University PhD.

Faller, Martina. 2000. Dimensional adjectives and measure phrases in vector space semantics. In M. Faller, S. Kaufmann and M. Pauly (eds.), *Formalizing the Dynamics of Information,* 151-170. CSLI Publications, Stanford.

Fintel, Kai von. 1994. *Restrictions on Quantifier Domains*. UMass PhD.

Francez, Itamar and Andrew Koontz-Garboden. 2011. Semantic variation and the grammar of property concepts. ms.

Grano, Thomas and Christopher Kennedy. 2012. Mandarin transitive comparatives and the grammar of measurement. *Journal of East Asian Linguistics,* **21**:219-266.

Heim, Irene. 1985. Notes on comparatives and related matters. ms. University of Texas, Austin.

Heim, Irene. 2001. Degree operators and scope. In C. Féry and W. Sternefeld (eds.) *Audiatur Vox Sapientiae: A Festschrift for Arnim von Stechow*, 214-239. Berlin: Akademie Verlag.

Hoeksema, Jack. 1983. Negative polarity and the comparative. *Natural Language & Linguistic Theory* **1.3**:403-434.

Kennedy, Chris. 2007a. Standards of comparison. Handout for Colloque de Syntaxe et Semantique de Paris, 6 October, 2007.

Kennedy, Christopher. 2007b. Vagueness and grammar: The semantics of relative and absolute gradable adjectives. *Linguistics and Philosophy* **30.1**:1-4.

Li, Xiao. 2009. *Degreeless Comparatives* Rutgers PhD .

Merchant, Jason. 2012. Genitives of comparison in Greek. In K. Chatzopoulou, A. Ioannidou, and S. Yoon (eds.), *9th International Conference on Greek Linguistics 2009.*

Murphy, M. Lynne. 2006. Semantic, pragmatic and lexical aspects of the measure phrase + adjective construction. *Acta Linguistica Hafniensia* **38**:78-99.

Pancheva, Roumyana. 2006. Phrasal and clausal comparatives in Slavic. In J. Lavine, S. Franks, M. Tasseva-Kurktchieva and H. Filip (eds.) *Formal Approaches to Slavic Linguistics* (*FASL*)14: The Princeton Meeting, 236-257.

Partee, Barbara H. 1987. Noun phrase interpretation and type-shifting principles. In J. Groenendijk, D. de Jongh, and M. Stokhof (eds.), *Studies in Discourse Representation Theory and the Theory of Generalized Quantifier*s, 115-143. GRASS 8, Foris, Dordrecht.

Rett, Jessica. 2008a. Antonymy and evaluativity. In Tova Friedman and Masayuki Gibson (eds.) *Semantics and Linguistic Theory (SALT) 17*, 210–227. Ithaca, NY: CLC.

Rett, Jessica. 2008b. *Degree Modification in Natural Language* Rutgers PhD.

Sawada, Osamu and Thomas Grano. 2011. Scale Structure, coercion, and the interpretation of measure phrases in Japanese. *Natural Language Semantics* **19**:191-226.

Schauber, Ellen. 1979. *The Syntax and Semantics of Questions in Navajo.* MIT PhD.

Schwarz, Bernhard. 2010. A note on *for*-phrases and derived scales. Handout for talk at Sinn und Bedeutung 15, September 9-11, 2010.

Schwarzschild, Roger. to appear. Comparative markers and standard markers. In M.Y. Erlewine and Y. Sudo (eds.) *MIT Conference on Comparatives*, Cambridge, MA: MIT Working Papers in Linguistics.

Svenonius, Peter. 2010. Spatial P in English. In G. Cinque and L. Rizzi (eds.) *Mapping Spatial PPs: The Cartography of Syntactic Structures, Volume 6 (Oxford Studies in Comparative Syntax)*, 127-160. Oxford University Press.

Winter, Yoad. 2005. Cross-categorial restrictions on measure phrase modification. *Linguistics and Philosophy* **28**: 233–267.

Xiang, Ming. 2005. *Some Topics in Comparative Constructions*, MSU PhD.

Young, Robert W. and William Morgan. 1987. *The Navajo Language*: *A Grammar and Colloquial Dictionary*, Albuquerque: University of New Mexico Press.

Zwarts, Joost. 1997. Vectors as relative positions: A compositional semantics of modified PPs. *Journal of Semantic*s, **14**:57–86.

Roger Schwarzschild
18 Seminary Place
New Brunswick, NJ 08901
rogerschwarzschild@gmail.com